

and auxiliary machinery and boilers in a modern steamship involve great responsibility, and an interesting section of the book is devoted to the discussion of the preservation and repair of boilers, the adjustment of machinery, and the duties of the watch-keeping engineer. A comparatively brief sketch is given of the modern theory of the resistance experienced by ships when moving through water, and of the conditions influencing the efficiency of propellers. In all cases the author illustrates his conclusions by modern instances and recent experiments, showing himself to have been a diligent student of published data. This is a distinctive feature of the book throughout.

The final section describes "recent developments" in marine engineering, including marine steam turbines and the applications of internal-combustion engines to ship propulsion. The Parsons type of turbine naturally receives most attention, having been applied so much more extensively than any other type, and the descriptions and illustrations are excellent. The arrangements of turbine machinery described include those of battleships, cruisers, the latest Cunarders, and certain small, swift vessels of the destroyer class. A summary of the results obtained on contract trials and actual service is also given. It is interesting to note how rapidly the Parsons system has made its way abroad as well as at home. So far, its only rival—and that at a very great distance—is the Curtis turbine, which has been successfully applied in the United States scout-cruiser *Salem*, of which the contract trials took place subsequently to the completion of the book.

In regard to internal-combustion engines the author gives much information, indicating the features in which they must still be regarded as experimental, as well as those in which they promise a possibility of further advances in speed and fuel-economy.

The volume is well produced, has a good index, and contains about 400 illustrations. It deserves and will secure a good reception from all who are interested in the subjects of which it treats. The author has the courage of his opinions, and, in not a few instances, exception may be taken to his conclusions; but in all cases the materials for judging independently are given, and readers can claim no more.

W. H. WHITE.

THE MOON'S MOTION.

The Inequalities in the Motion of the Moon due to the Direct Action of the Planets. By Prof. E. W. Brown, F.R.S. Pp. xii+93. An Essay which obtained the Adams Prize in the University of Cambridge for the Year 1907. (Cambridge: University Press, 1908.) Price 6s. net.

PROF. BROWN is much to be congratulated on having at length written the word "Finis" to his lunar theory. His achievement has been a very great one, for he has completely solved the problem that he had proposed to himself, viz. the motion of the moon under the attraction of known bodies; he has pushed his solution sufficiently far beyond the

standards required by observation to cover any probable increase in the accuracy of observation during the near future; his mathematics have been elegant, and his numerical computations performed under systems of check that command, not only his own confidence in their accuracy, but that of his readers. At last, therefore, we are entitled to say that any discrepancy between theory and observation must be attributed to fresh causes and not to imperfect calculation. A similar remark has somewhat readily been made before after the completion of other lunar theories, but a degree of numerical accuracy far beyond Hansen or Delaunay may safely be claimed for Prof. Brown's theory.

The memoir especially under review is the investigation of the direct action of the planets, which was recently awarded the Adams prize in the University of Cambridge. The subject was unknown to Hansen, whose tables are still in use. In 1876 Prof. Newcomb discovered an empirical term in the moon's motion. Shortly afterwards Mr. Nevill attributed this term to the action of Jupiter. Some years then elapsed, and Dr. G. W. Hill gave a computation of the new term, and a little later Radau computed a large number of planetary terms in the moon's longitude. It is remarkable that both Hill and Radau gave $0''.90$ as the coefficient of Newcomb's term, and both of them were 20 per cent. in error. Radau's results are in other respects free from sensible error, and it is unfortunate that the term which started the whole subject should have been the one most difficult to calculate with accuracy. Quite recently Prof. Newcomb and Prof. Brown have published their researches. It is clear that the latter has reached a higher order of accuracy, but the former's memoir is probably amply good enough for comparison with observation. They agree in an increased coefficient of $1''.1$ for Newcomb's empirical term. It is not possible to compare either investigation with the other at any intermediate stage before the conclusion.

This is perhaps the time to give an answer to the question, How will the actual motion of the moon agree with Prof. Brown's theory? We have already expressed our belief that any want of agreement will point to the action of unknown causes. Possibly, therefore, Prof. Brown's work will be even of more importance if his tables fail to predict the motion of the moon than if they succeed.

As regards short-period inequalities, we believe that Prof. Brown's tables will be practically perfect. We should like, however, to invite the attention of astronomers in thirty years' time to one point. Let every discordance between observation and tabular position be multiplied by the sine and cosine of the moon's longitude and the mean taken. If this be done for the last fifty years, the result is too large to attribute to accidental error; nor will the alteration of the moon's parallax and the insertion in the new tables of a Venus term with coefficient $0''.7$ entirely remove the difficulty. Possibly the past observations have been affected by a systematic error, but be the cause what it may, the point is worth remembering and looking into when the proper time comes.

As regards inequalities of period over twenty years, Prof. Brown has thrown no fresh light upon the matter. Let us say quite plainly that we do not believe this to be Prof. Brown's fault. We do not doubt that his work is accurate, and because he has not explained certain long-period inequalities which appear to exist, we believe that the cause of those inequalities is something outside the problem that Prof. Brown proposed to himself. Nevertheless, we have only to look down the list of mean errors for each of the last fifty years to see that there still exists some unsolved mystery.

The mystery becomes greater the further we go back. Prof. Newcomb has investigated and is still investigating the occultations of the seventeenth and eighteenth centuries. In 1883 an empirical correction was introduced into the ephemerides to satisfy these occultations, and Prof. Brown's researches do not bring forward any fresh term that will take the place of Prof. Newcomb's empirical term.

If we go further back still, matters are worse. Many years ago Prof. Celoria traced the eclipses of 1239 and 1241 across Europe, collecting records from large numbers of different sources, and he pointed out a disagreement with the paths as calculated from Hansen's tables. The discordance becomes more accentuated as we go further back, until Prof. Newcomb declared that all records of ancient solar eclipses were to be put aside as untrustworthy. We do not think that this conclusion will stand, for two or three investigators have shown that the discordance between the records and the tables is not haphazard, but obeys an empirical law to which different forms may be given, but which is in its effect upon eclipse tracks very much the same in the different investigations referred to. Our conclusion, therefore, is that a splendid mathematical achievement has been performed, but that our power of predicting the motion of the moon has not been increased in a corresponding degree.

PRO'S AND CON.'S OF DARWINISM.

- (1) *Selektionsprinzip und Probleme der Artbildung: ein Handbuch des Darwinismus.* By Prof. Ludwig Plate. Dritte, sehr vermehrte Auflage. Pp. viii + 493; 60 figs. (Leipzig: W. Engelmann, 1908.) Price 12 marks.
- (2) *Die Lehre Darwins in ihren letzten Folgen.* By Max Steiner. Beiträge zu einem systematischen Ausbau des Naturalismus. Pp. vii + 244. (Berlin: Ernst Hofmann and Co., 1908.) Price 3 marks.

(1) **P**ROF. L. PLATE'S "Selektionsprinzip" has been so much expanded in its third edition that it deserves to be called "a handbook of Darwinism." It is a careful and thoughtful text-book by a thorough-going Darwinian, who is at the same time a believer in the transmission of acquired characters. In the first chapter he considers the objections to Darwinism. These may be relatively unimportant, e.g. that Darwinism does not account for the origin of variations, that artificial and natural selection are not really analogous, that the struggle for existence is not selective. But there are other objections which

are more essential, e.g. that minute changes cannot have selective value, that the process of natural selection cannot be seen occurring, that the theory of selection starts from the fortuitous. It is useful to have a modern Darwinian's answers to these and other attacks on his faith, and it is much to be desired that those who rush into print with anti-Darwinian books and essays would read a work like Plate's, especially if they will not read Darwin.

The second chapter gives a careful discussion of the various forms of struggle and selection. The third discusses the auxiliary, or would-be auxiliary, theories—theories of sexual selection, struggle of parts, panmixia, germinal selection, and mutation; and the author deals in a strongly critical but temperate manner with the difficulties which beset these. He will have nothing to do with germinal selection and not much with Roux's "Kampf der Teile"; panmixia may account for degeneration, but not for rudimentation, and most of what is new in the mutation-theory is not true. Apart from selection, the conditions of evolution are heritability, variability, and isolation; and the discussion of these is admirable. One may not agree—and we certainly do not feel in any way convinced by the author's vigorous Lamarckism—but one must admit that the author's presentation is skilful and just. He states the experimental and other facts which lead him to think that we cannot dispense with modification-inheritance, and he sketches a hypothesis, not unlike Herbert Spencer's, of the passage of a specific influence from the peripheral parts of the soma to the peritremia of the germ-cells. Plate is far from thinking that the selection-theory clears up everything; it starts with growing and multiplying organisms which it does not explain; the conditions of variability and inheritance are still unknown; there are many unsolved problems. But instead of making a harsh alternative between the "Allmacht" or "Ohnmacht" of natural selection, what we have to do, as the author well indicates, is to test this and other formulæ in a critical yet fair-minded fashion. This is what he has aimed at in his book, and it seems to us that he has succeeded well, on the whole, at any rate, for now and again, e.g. in his remarks on the vitalists, he seems to us to be unnecessarily hot-blooded. We should like to know, for instance, where Dr. Hans Driesch spoke of a "Degeneration des Gehirns der Darwinisten." Is this not a fictitious quotation?

(2) The author of the second volume before us seems to think that Darwinism has been too much discussed as a biological theory, artificially abstracted from its social consequences. If we understand him, he seeks to put things right by showing what terrible consequences the theory involves. A scientific formulation is not to be judged by its applicability to the order of facts in relation to which it arose—that is a humdrum conventional inquiry which may be left to men like Prof. Plate—it must be judged by its human consequences! So Herr Steiner expounds with gusto his by no means favourable judgment of the metaphysic and ethic of Darwinism and its bearing on æsthetics and the valuation of life. He shows to